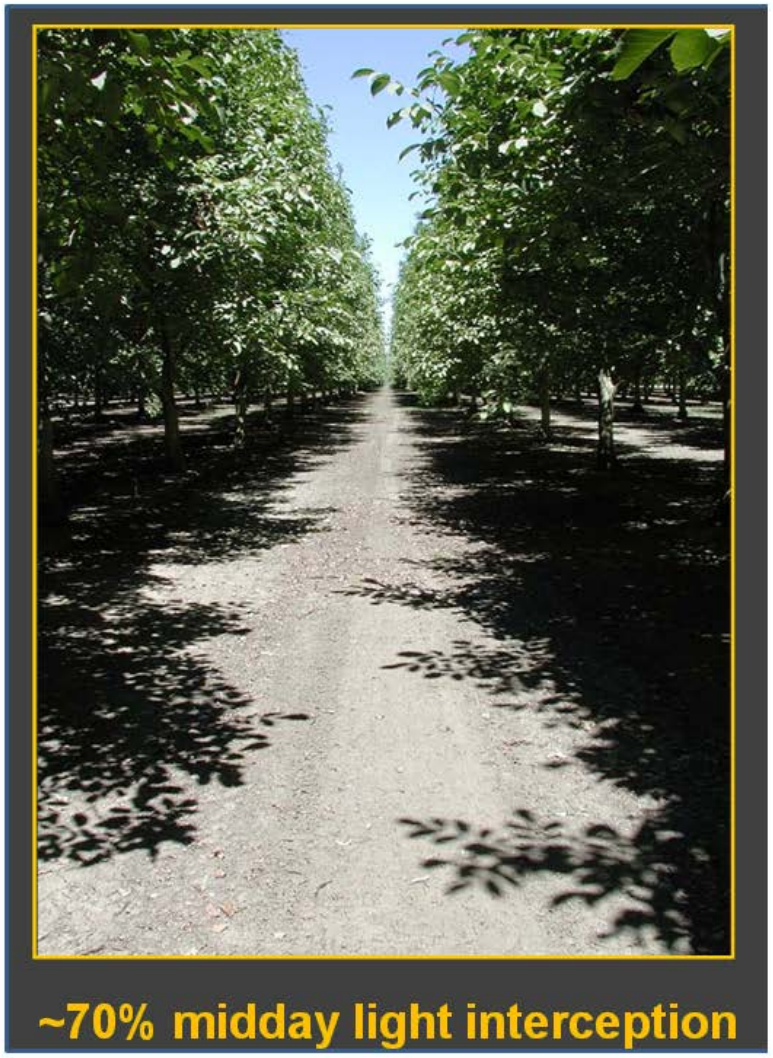
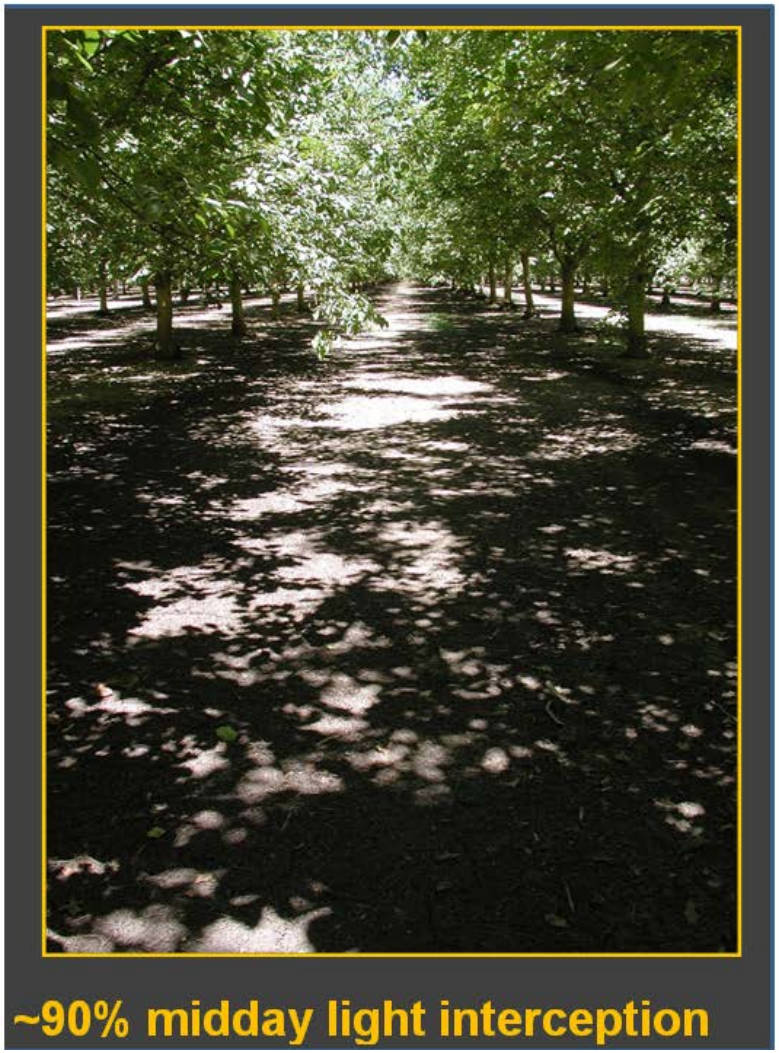
Orchard Design

Dr. Bruce Lampinen, Plant Sciences UC Davis/UC ANR



~70% midday light interception



~90% midday light interception

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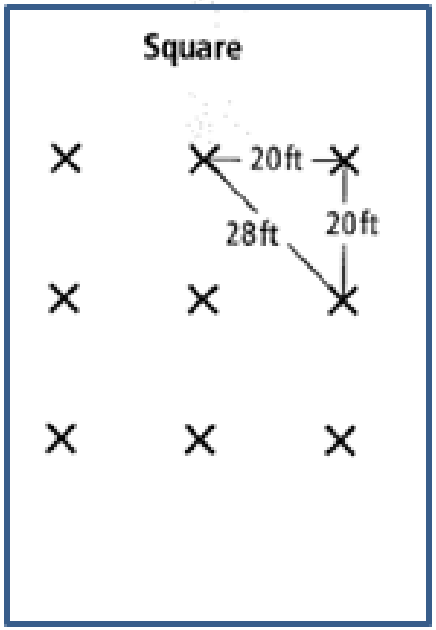
Agriculture and Natural Resources

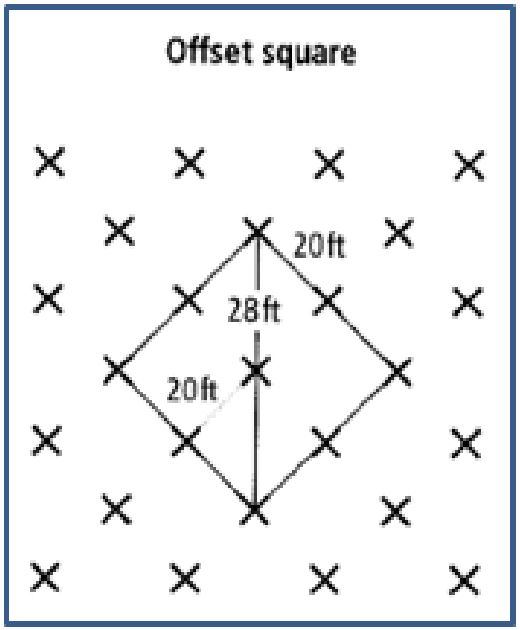
Factors influencing how fast an orchard comes into production:

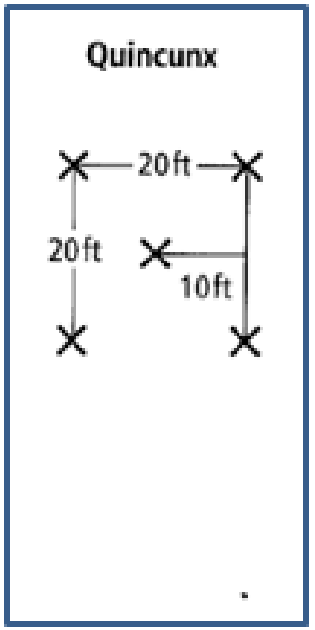
- Microclimate
- Soil characteristics
- Rootstock
- Variety
- **Tree spacing/configuration**
- Orchard floor management
- Pruning/training
- Irrigation management
- Nutrient management

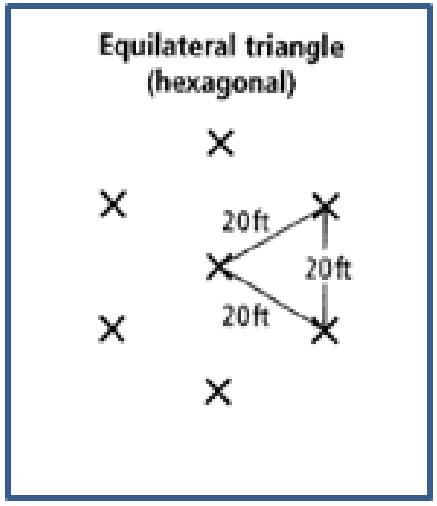
Once you have planted the orchard these choices can't be changed.

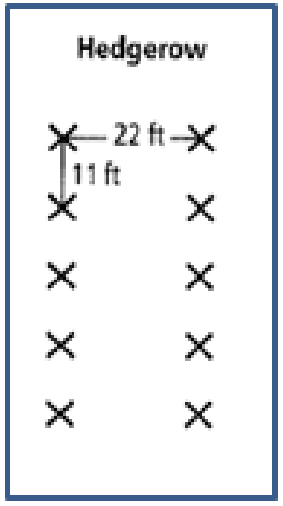
The goal- produce as many nuts as early as possible while developing a good tree and canopy structure

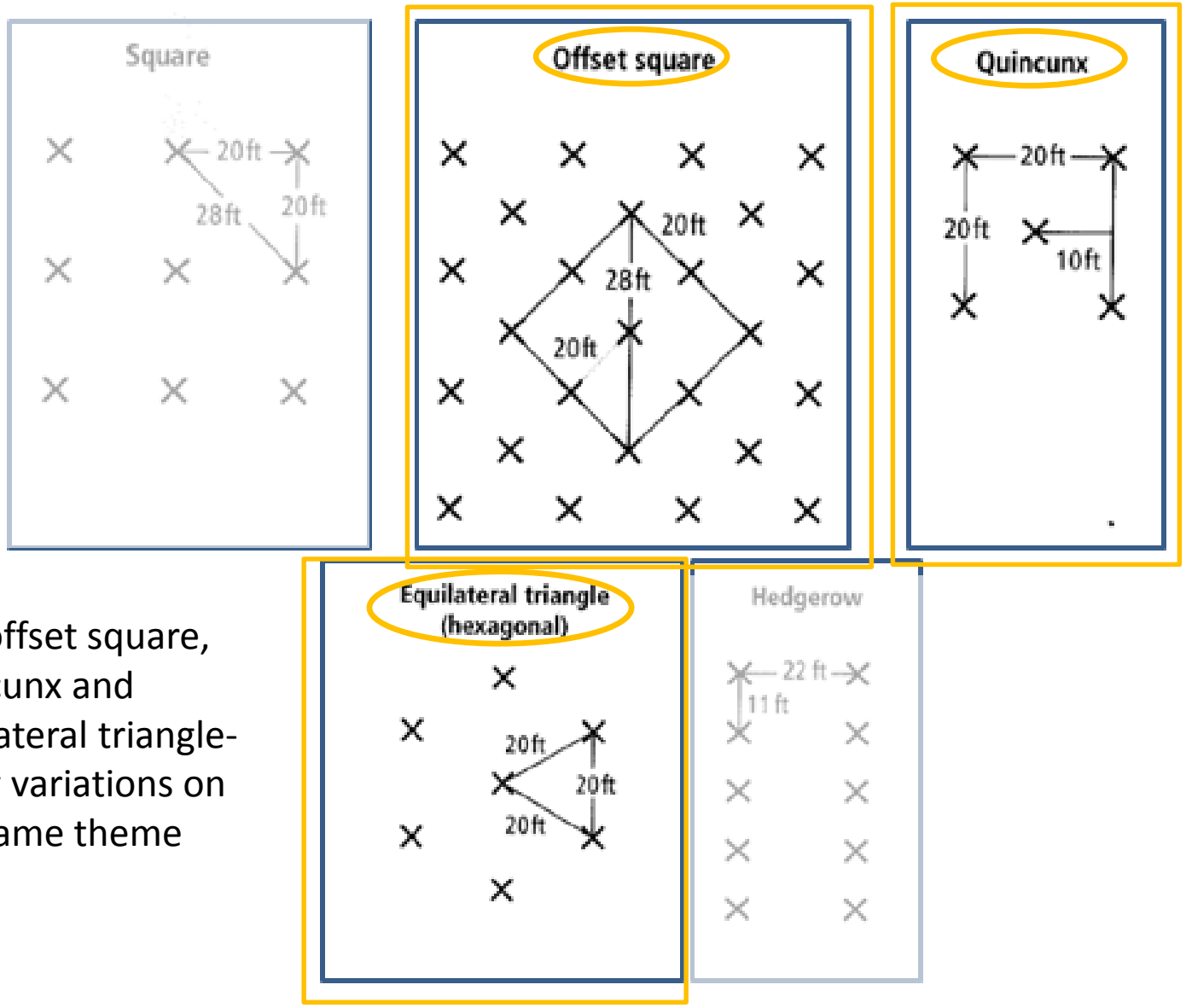

Square
20ft
28ft
20ft


Offset square
20ft
28ft
20ft

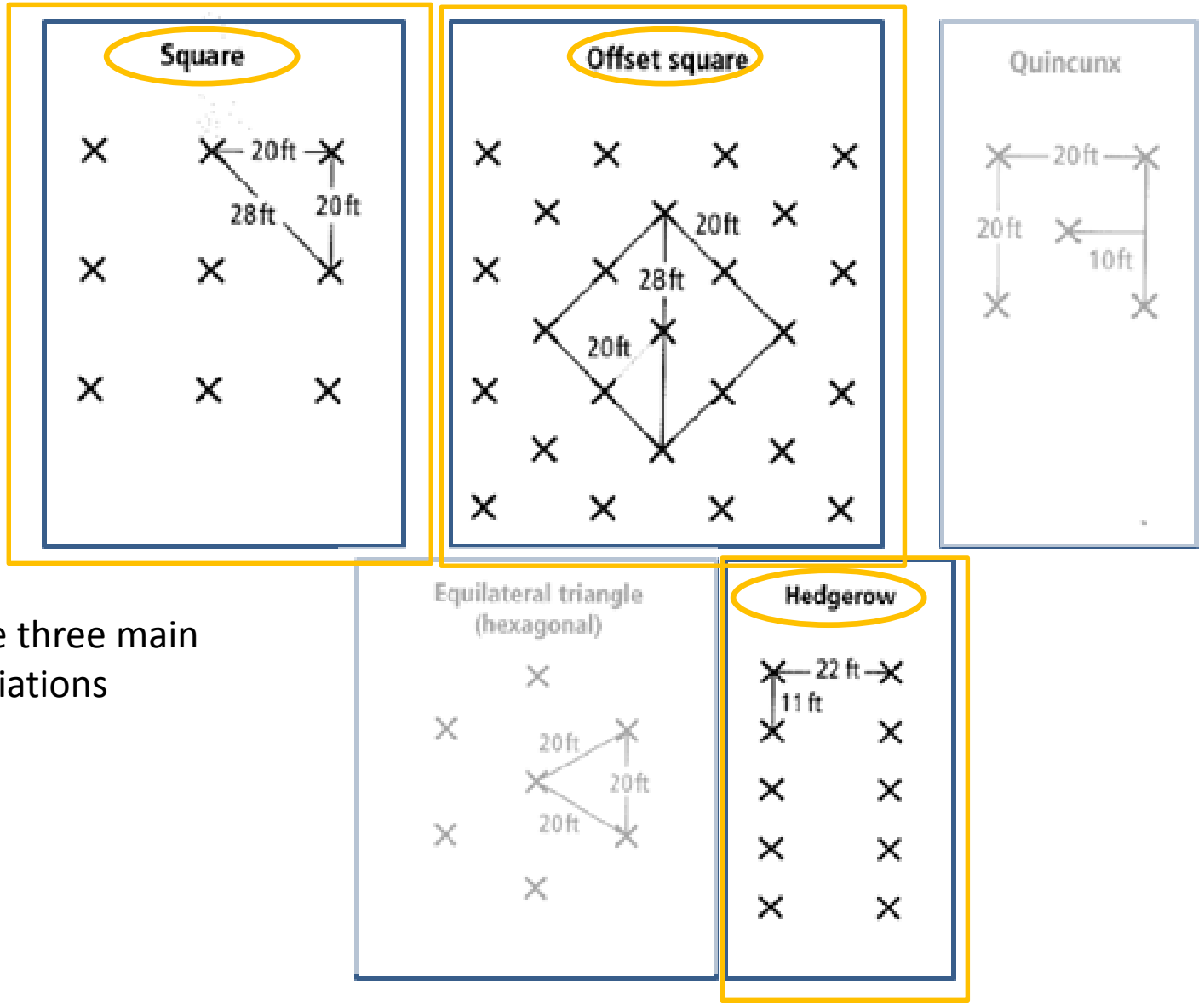

Quincunx
20ft
20ft
10ft


Equilateral triangle
(hexagonal)
20ft
20ft
20ft

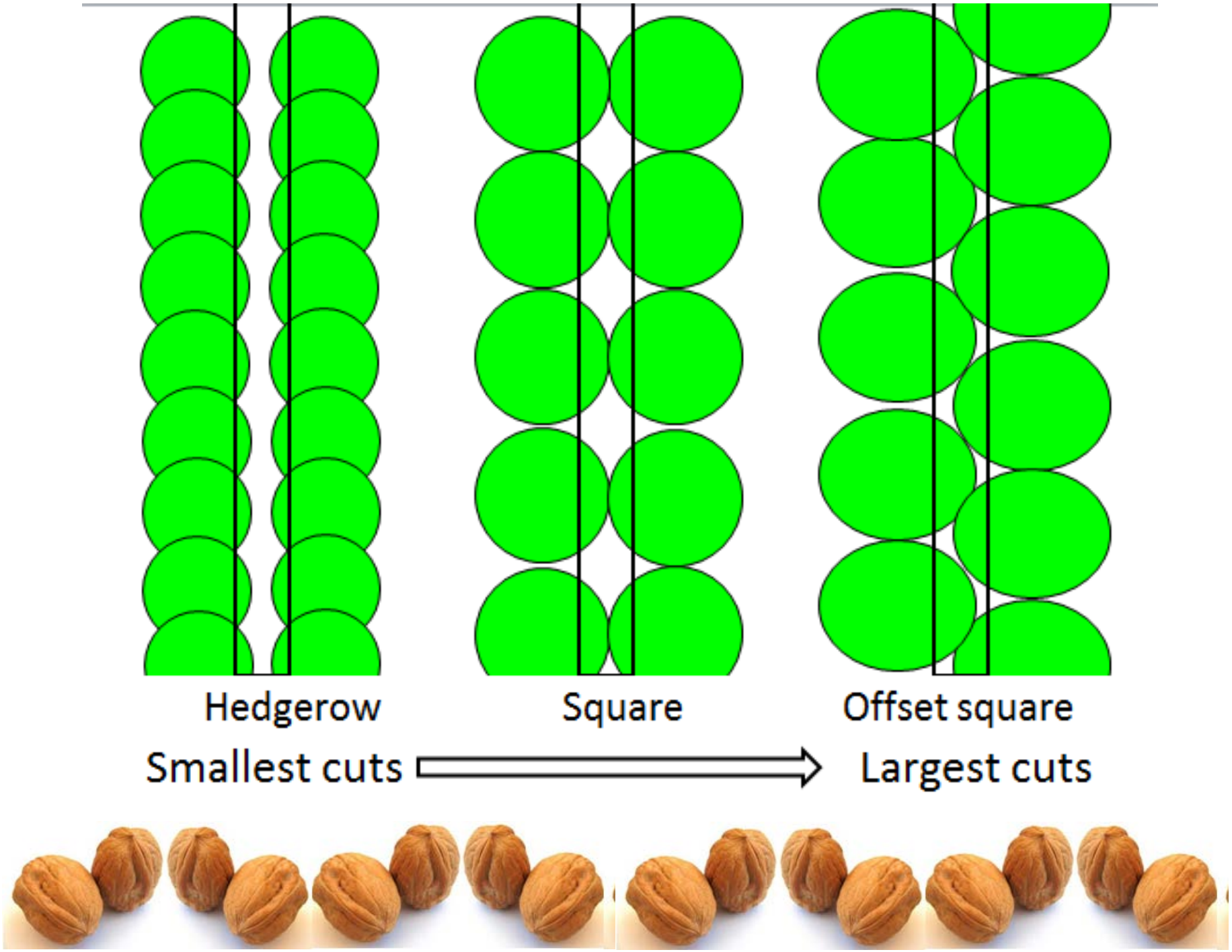

Hedgerow
22 ft
11 ft



The offset square, quincunx and equilateral triangle- really variations on the same theme

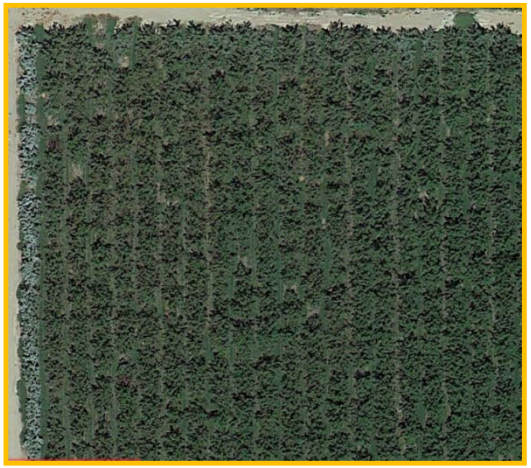


The three main variations


Hedgerow
Square
Offset square
Smallest cuts
Largest cuts

How do we compare the performance of these different planting/management systems- i.e. how do we quantify light interception/yield relationships?

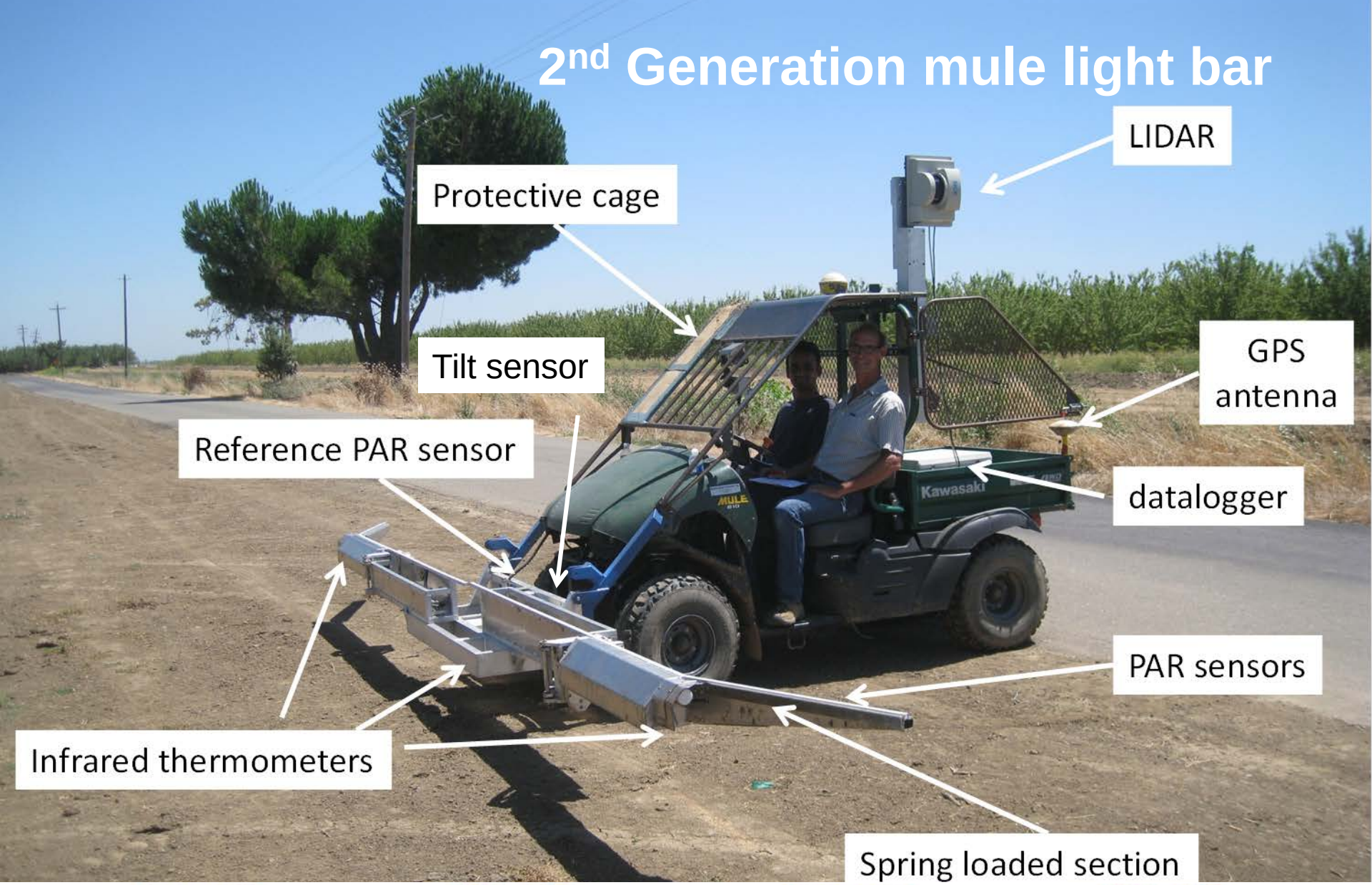
25’ x 24’ Tulare
(hand pruning, no hedging)



11’ x 22’ Chandler

25’ x 25’ Chandler
(hedged every 3rd row)

2nd Generation mule light bar



Mid-summer, drive down rows with Mule light bar

At harvest, pick up and weigh all nuts from same area


Honda motor and hydraulic pump
Fuel tank


Scale display
Trimble GPS unit
elevator

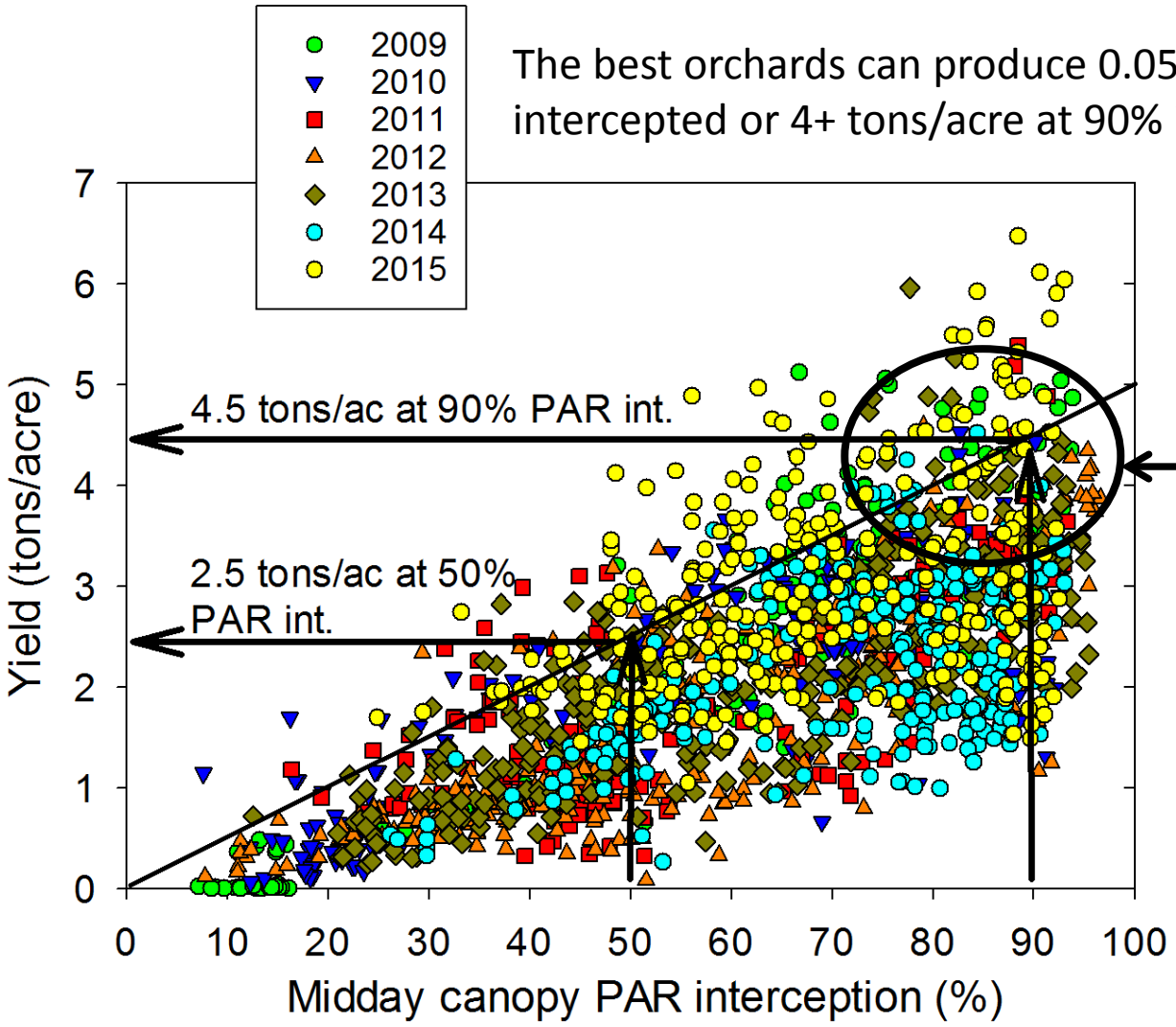

Auto sampler open to receive nuts


Hydraulically driven auger to deliver samples to rear


Samples are delivered to 5 gallon bucket at rear (much safer than old method of getting samples by hand)

Managing canopy size to maximize yield and quality

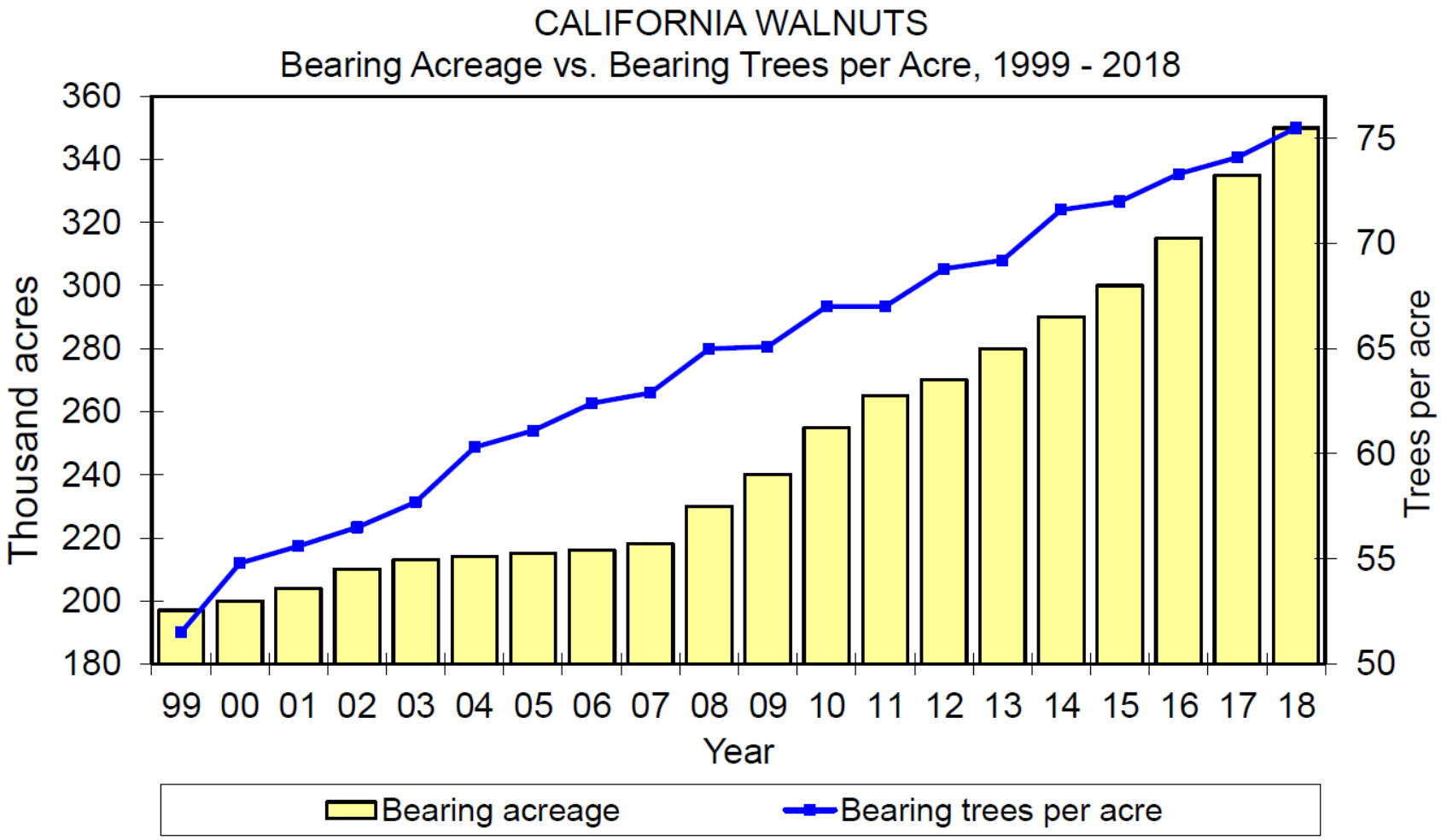
The best orchards can produce 0.05 tons per 1% PAR intercepted or 4+ tons/acre at 90% interception



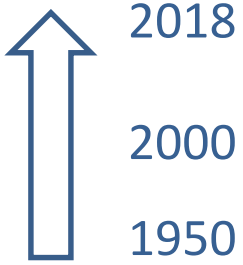
How do we maintain orchards in this area?

60’ x 60’ = 12.1 trees/acre

15’ x 21’ = 148 trees/acre
(12 times as many trees)



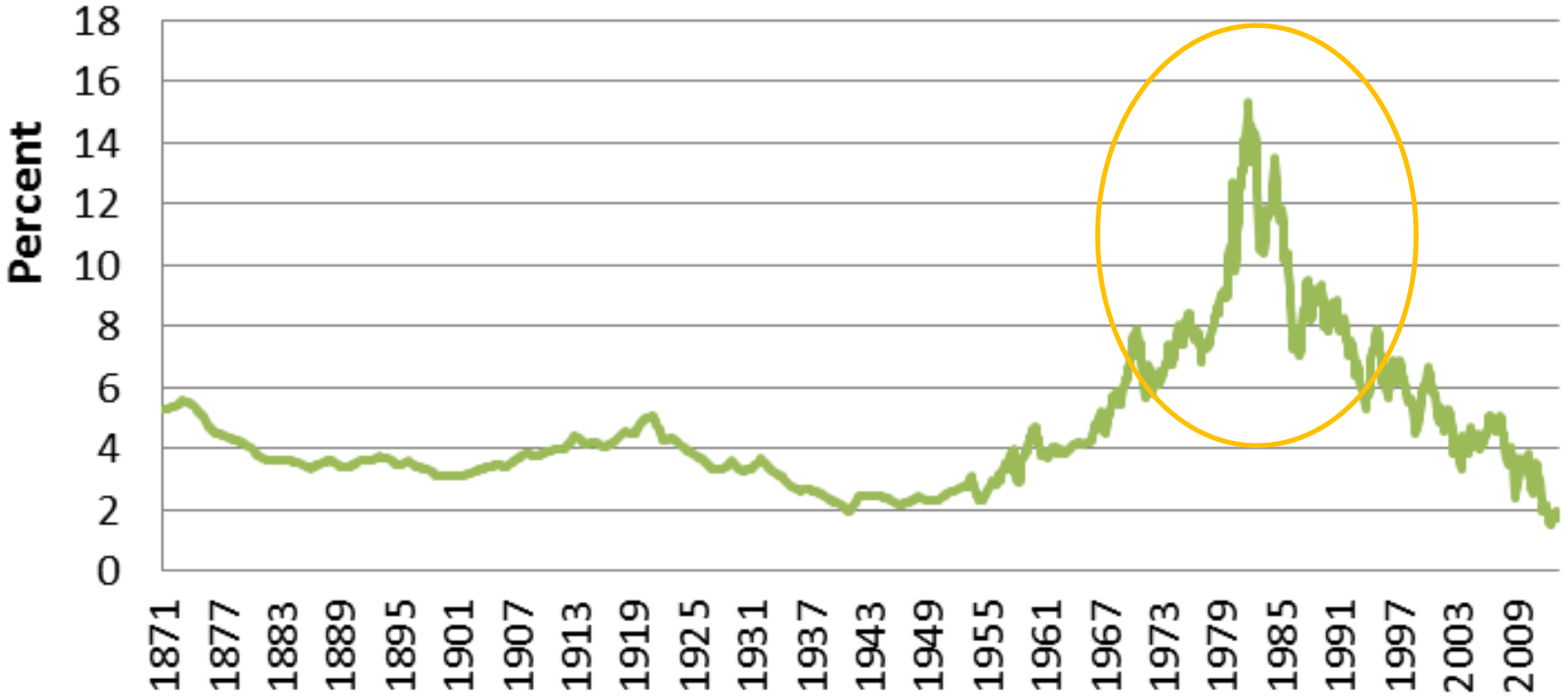
24.1’ x 24.1’ spacing = 75 trees/acre
25’ x 25’ spacing = 70 trees/acre
28’ x 28’ spacing = 55 trees/acre
30’ x 30’ spacing = 48 trees/acre
60’ x 60’ spacing = 12 trees/acre

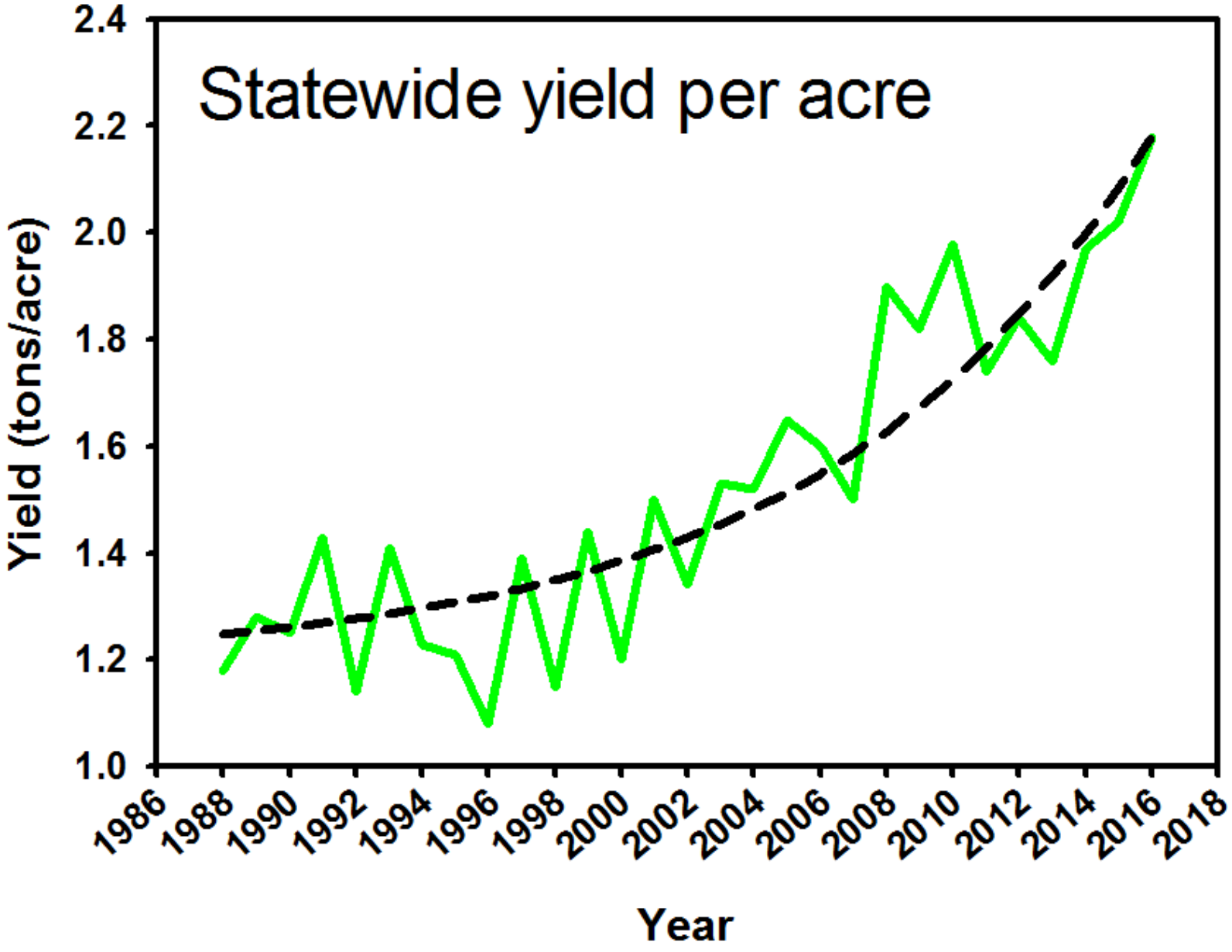


Rationale for hedgerows

- Earlier yields
- Tree loss not as important
  - If you lose a tree, tree next to it will fill in
  - Especially important in areas with Blackline
- Mechanical hedging for pruning
  - Relatively cheap and easy

US Long-Term Interest Rates
1871-2013

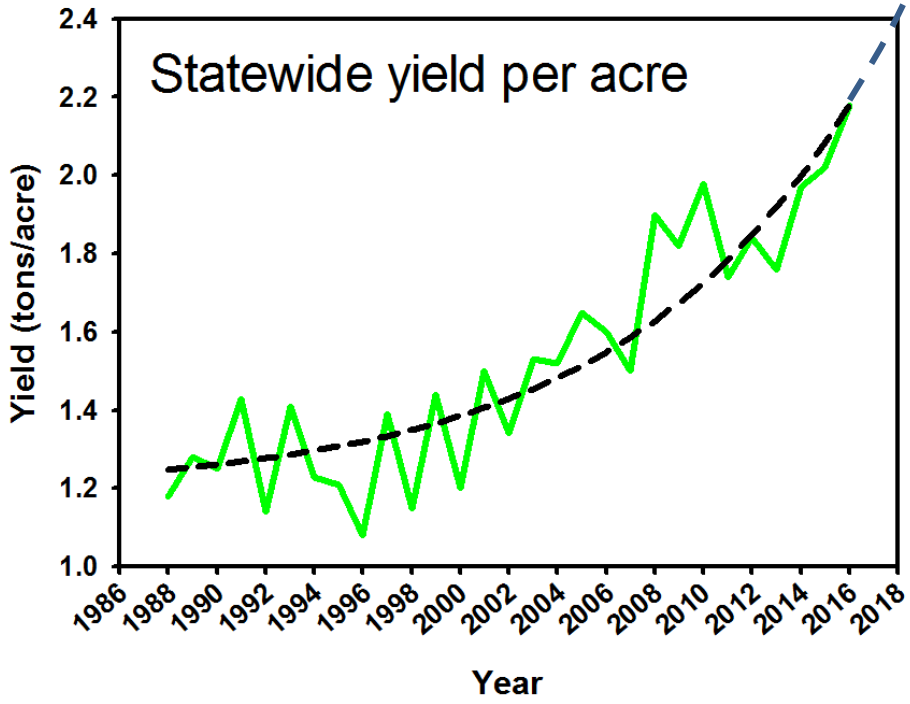



Statewide yield per acre
Yield (tons/acre)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year

Maximum near 4.5 tons/acre

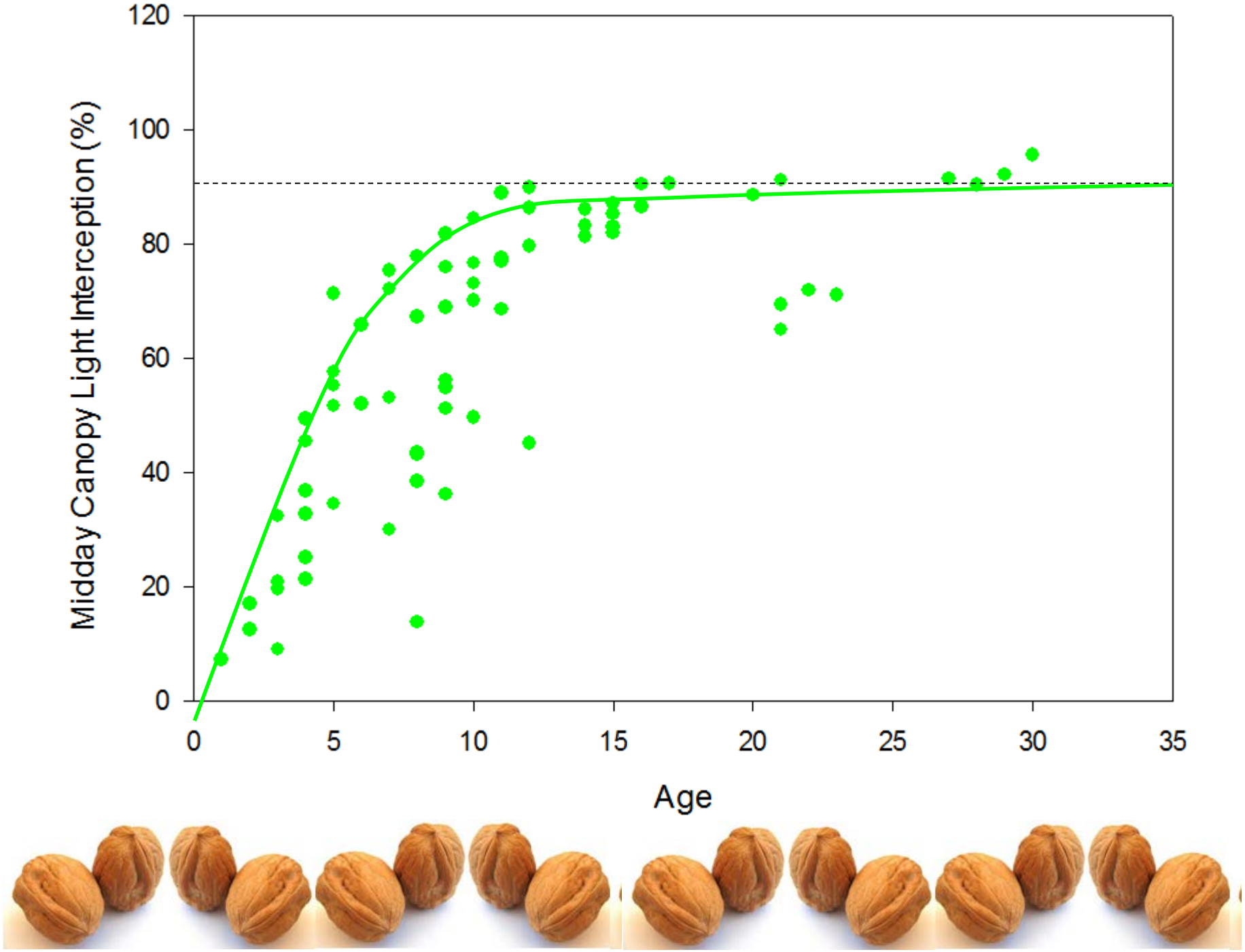
Percent of potential

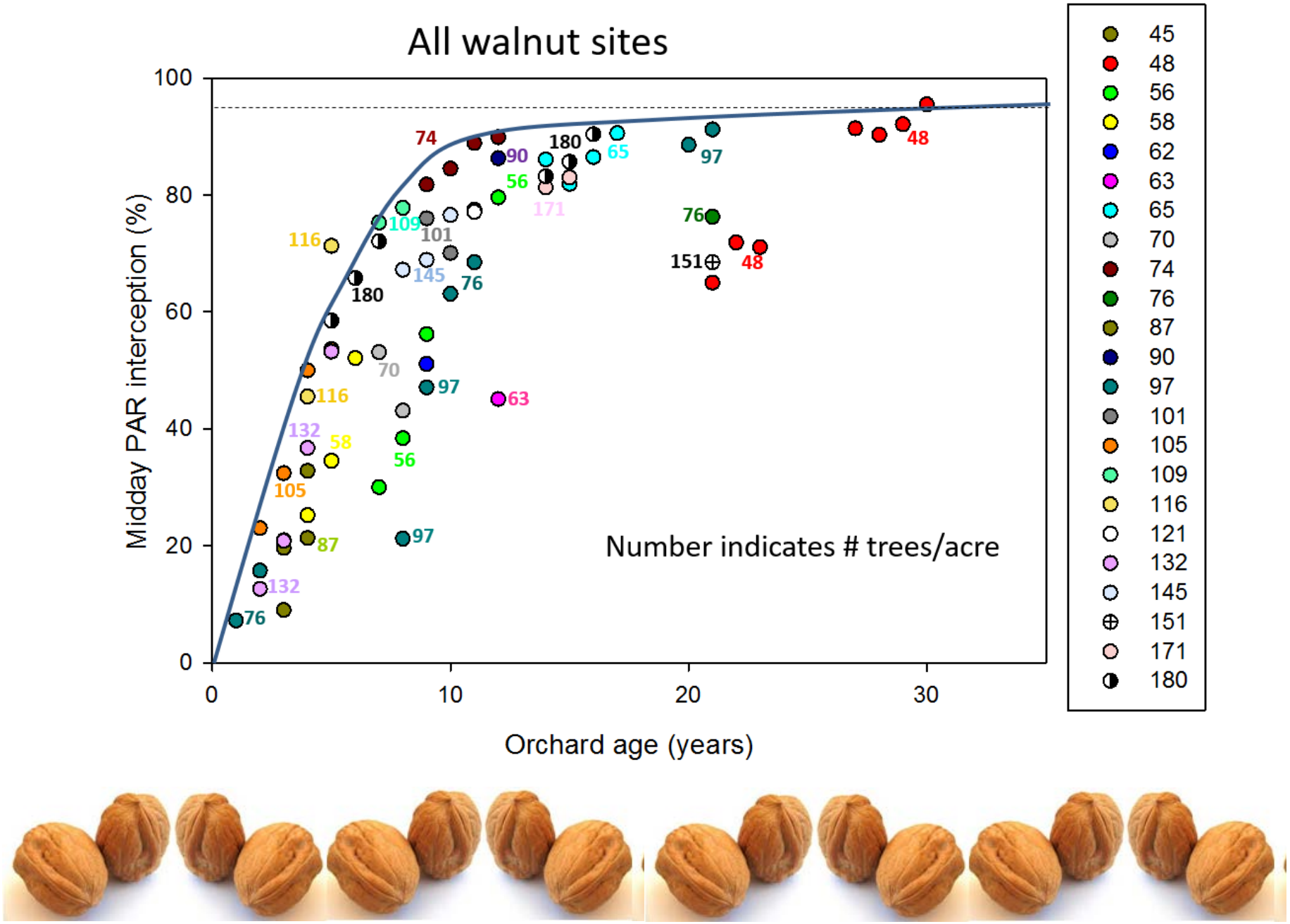
???? = 100%

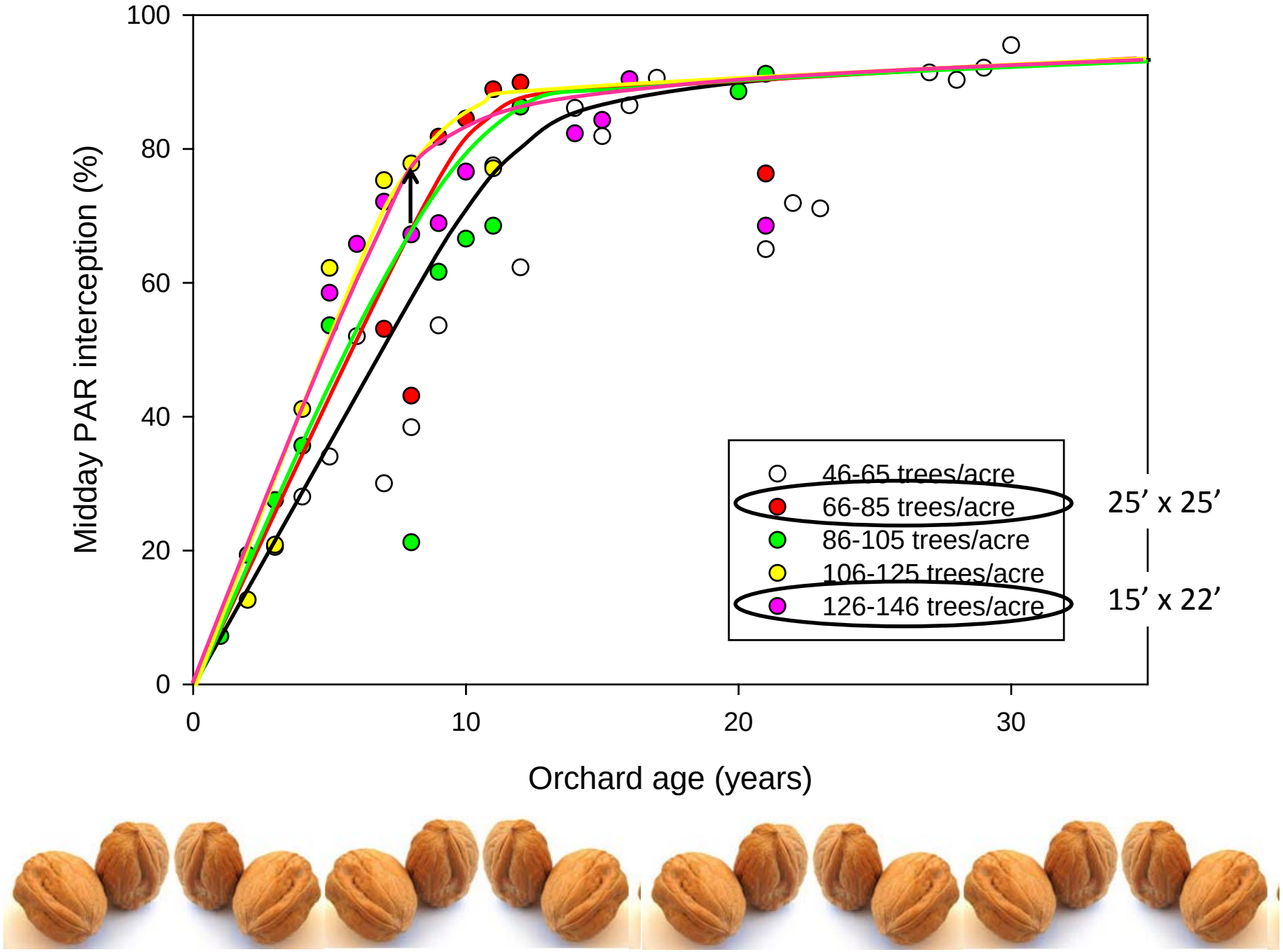


2016 = 49%

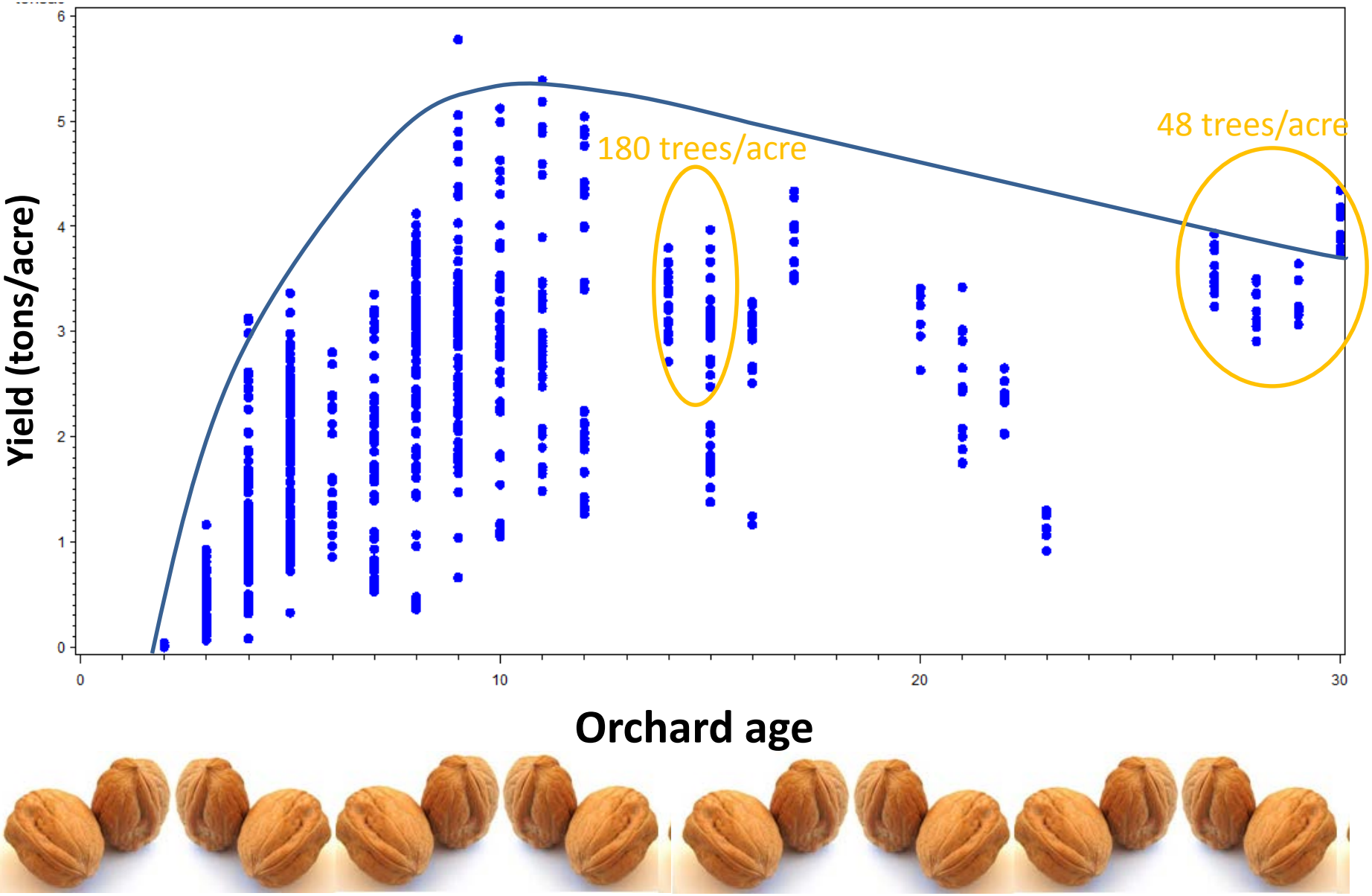
1988 = 28%


Midday Canopy Light Interception (%)
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
Age

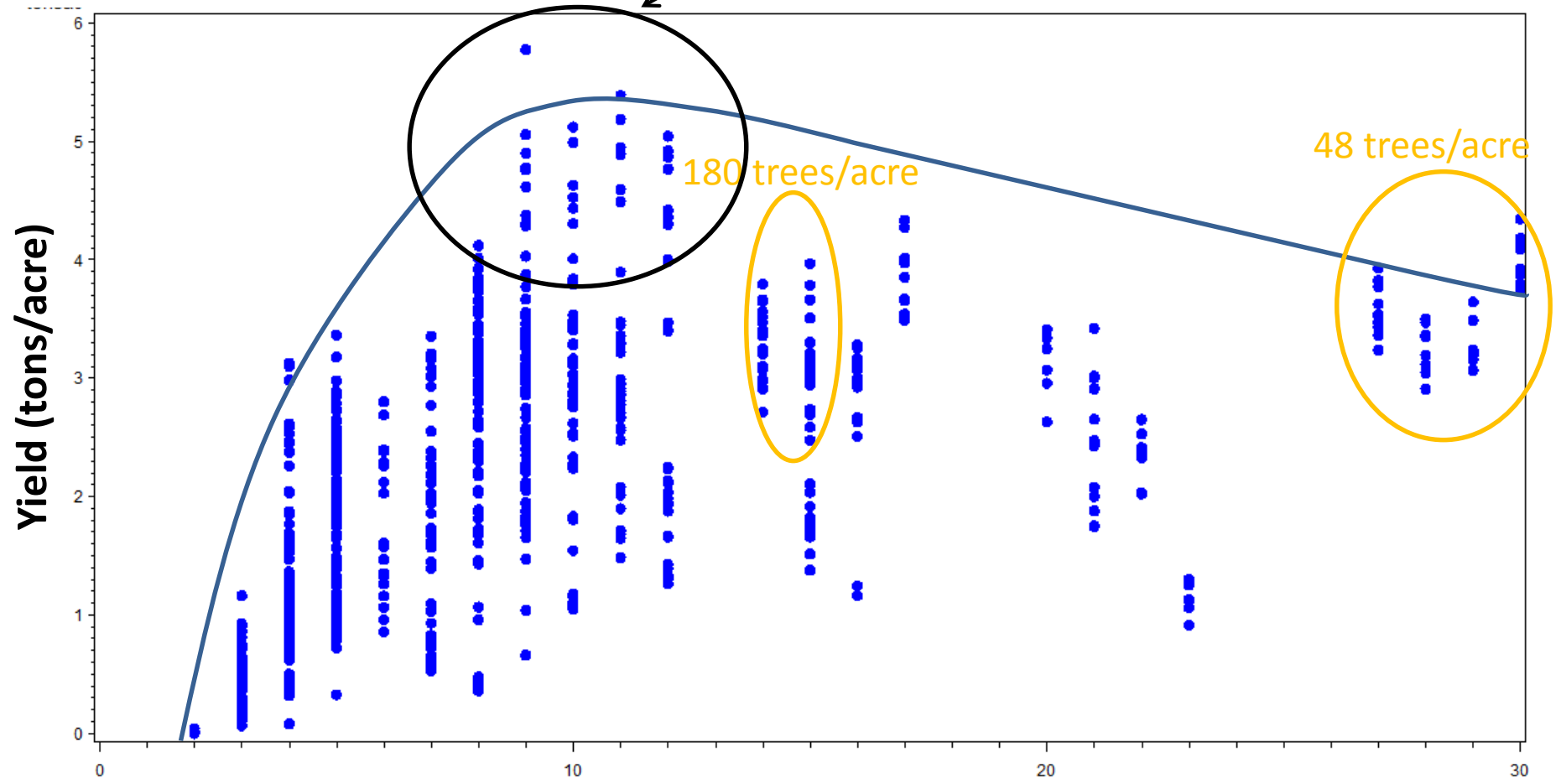

All walnut sites
Midday PAR interception (%)
Orchard age (years)
Number indicates # trees/acre
0
20
40
60
80
100
0
10
20
30
45
48
56
58
62
63
65
70
74
76
87
90
97
101
105
109
116
121
132
145
151
171
180

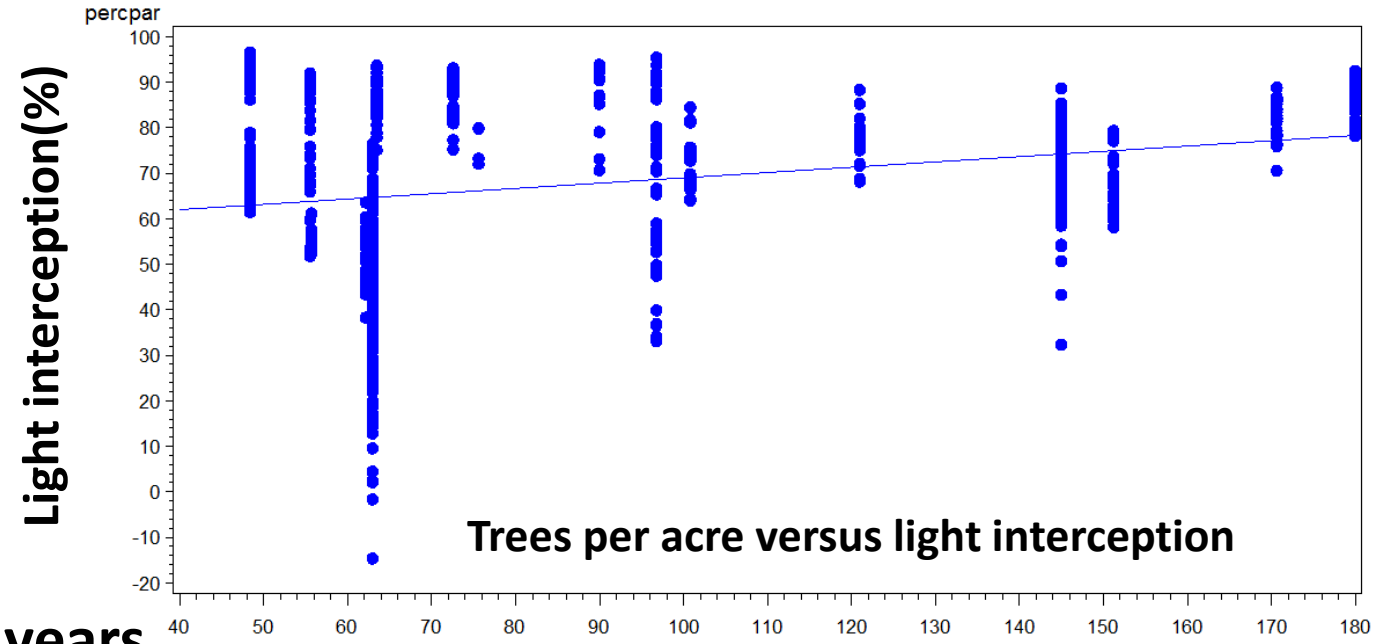

Midday PAR interception (%)
100
80
60
40
20
0
0
10
20
30
Orchard age (years)
46-65 trees/acre
66-85 trees/acre
86-105 trees/acre
106-125 trees/acre
126-146 trees/acre
25’ x 25’
15’ x 22’

Yield peaks at about 10-12 years of age

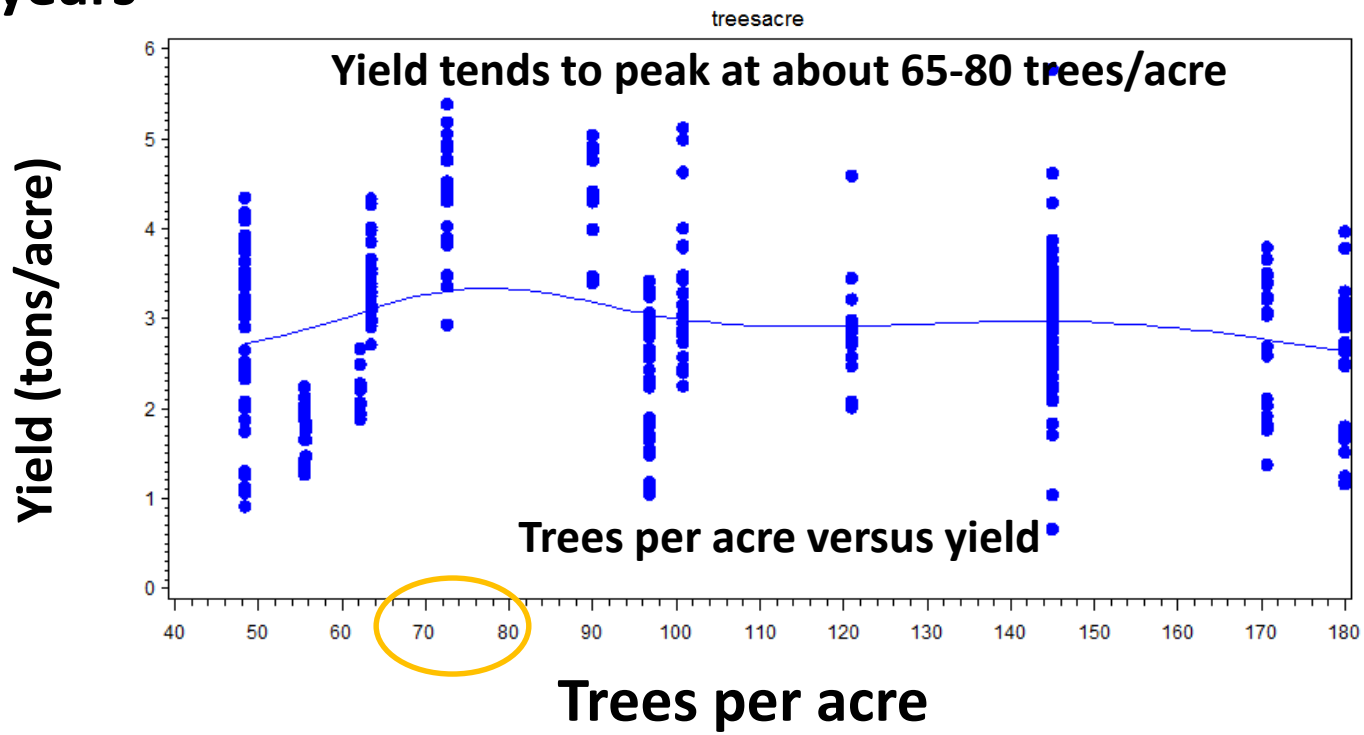


Very high yields tend to occur in years 7-11, before hedging or extensive hand pruning is required to deal with crowded conditions

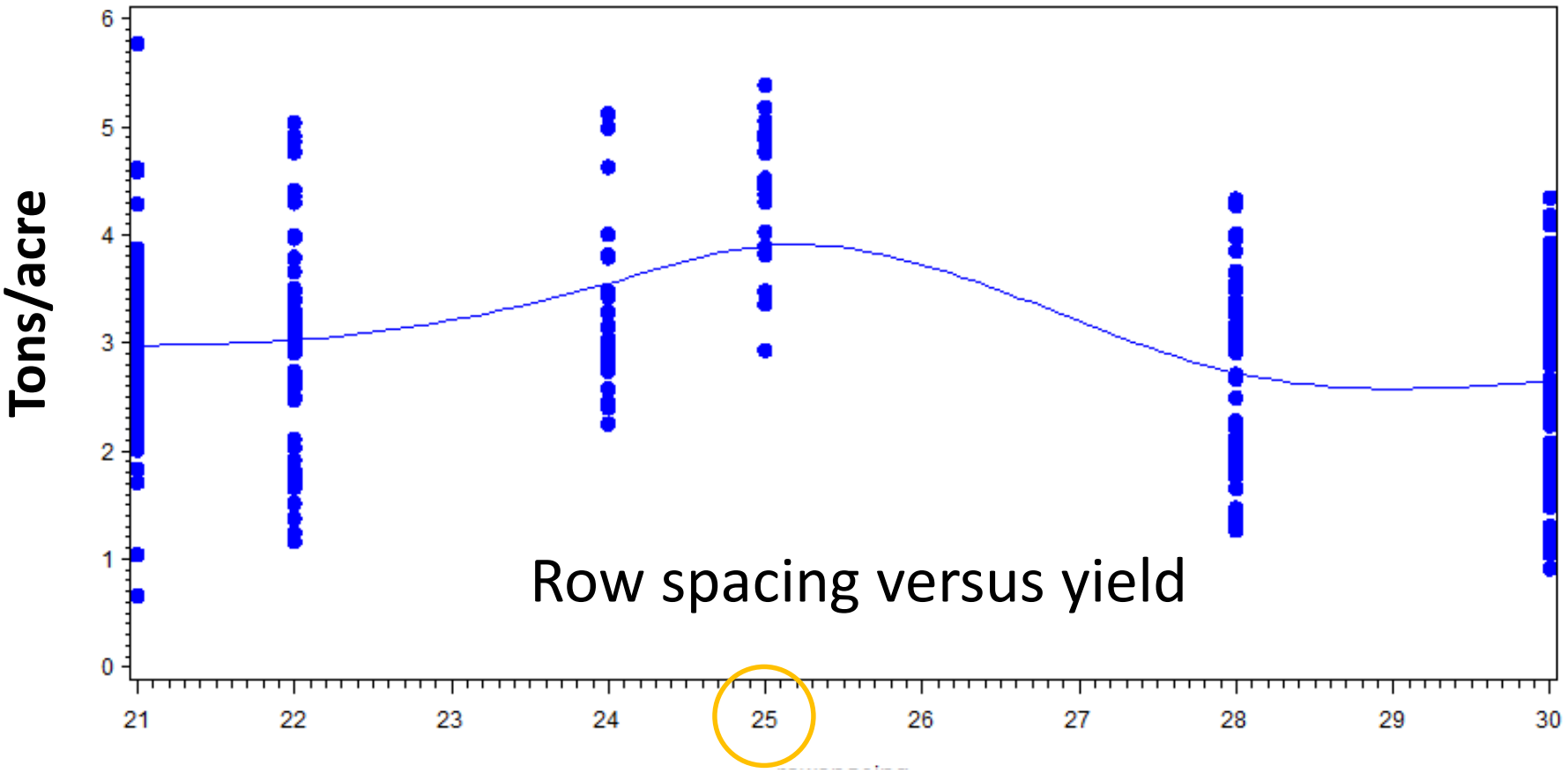




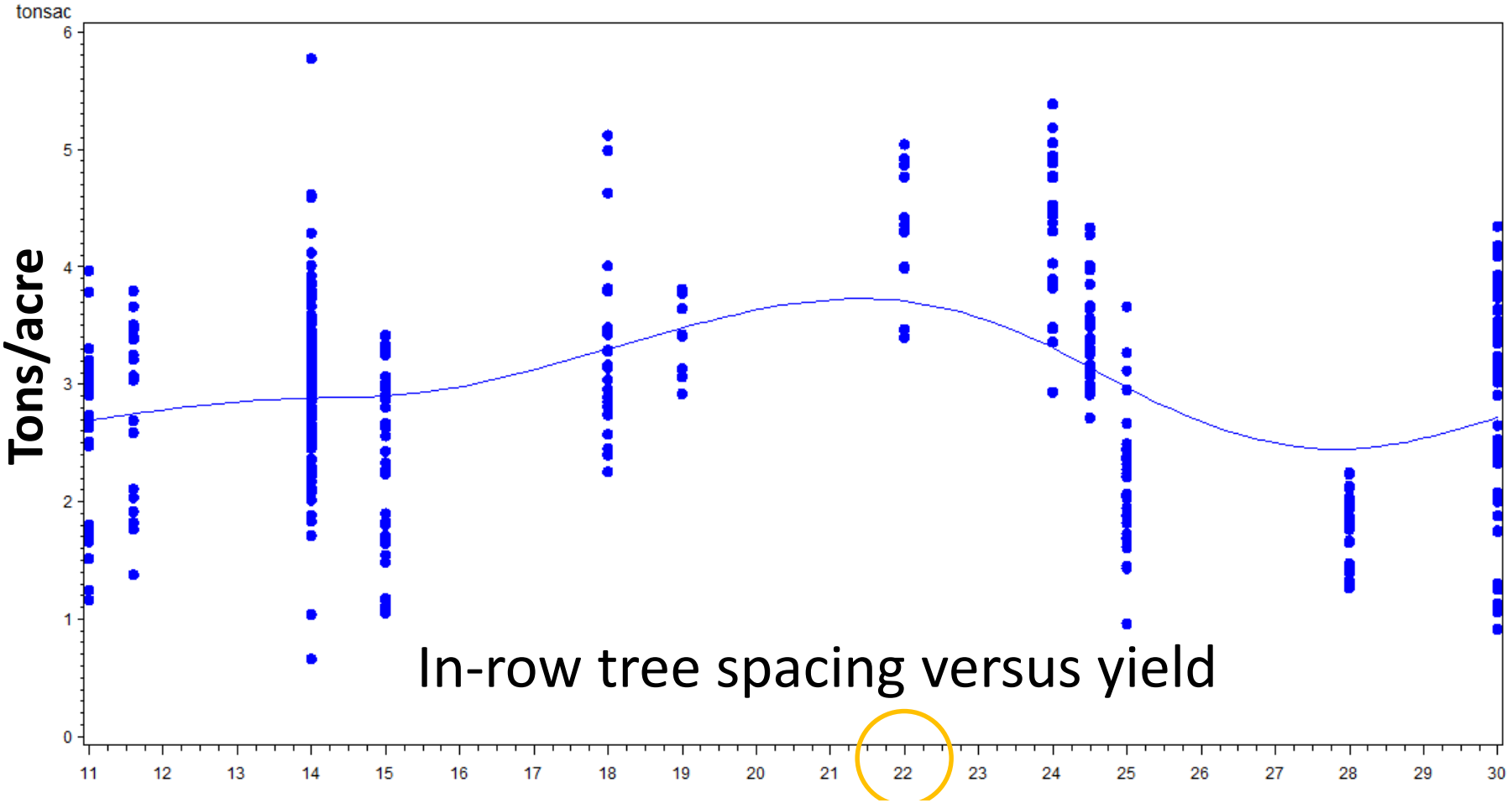
Orchard age>8 years

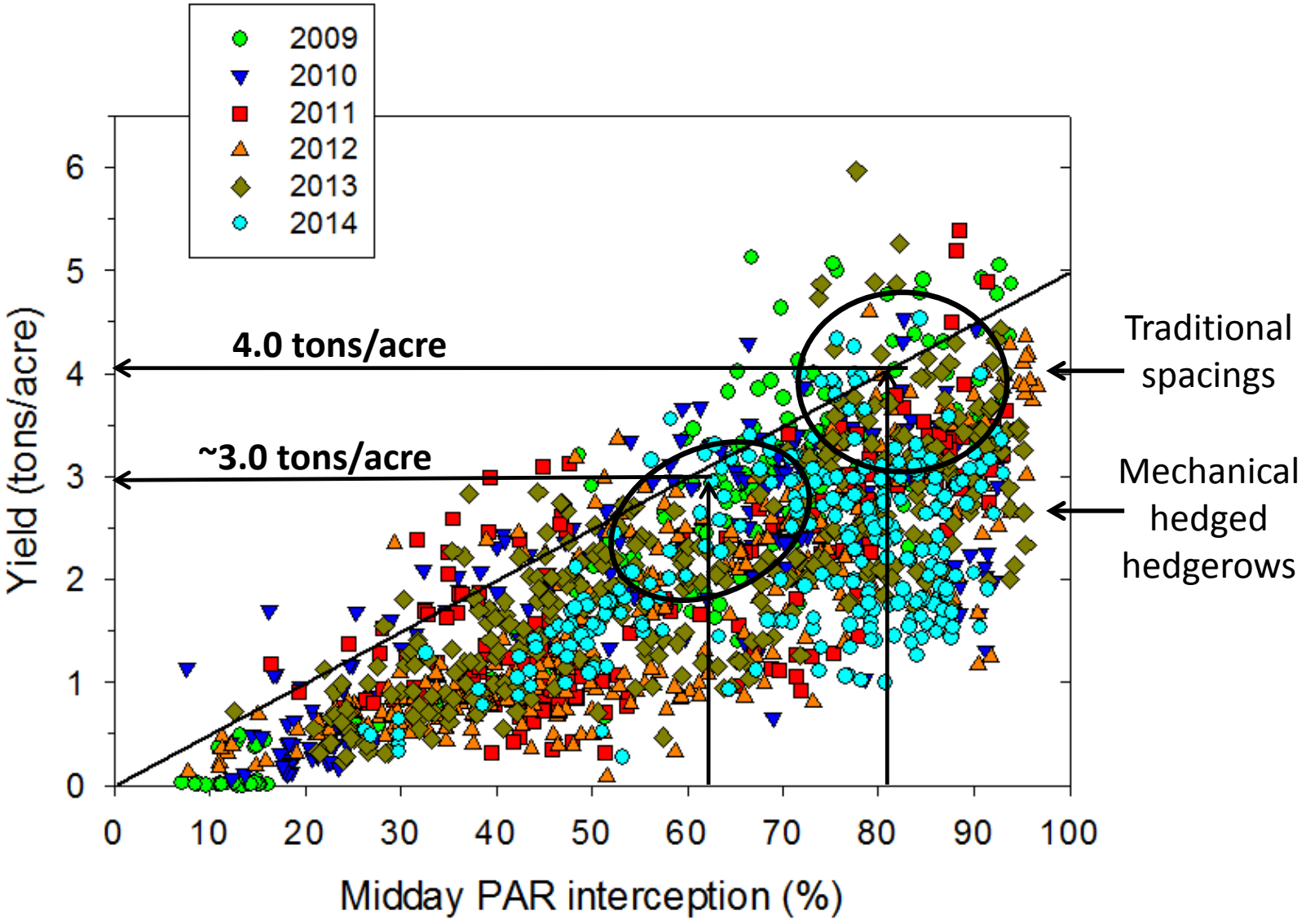


Orchard age>8 years



Orchard age>8 years





Potential production 0.05 tons/acre for each 1% of total PAR intercepted

Optimum appears to be at about 24’-26’ traditional square spacing and about 65-75 trees per acre. The highest yielding orchard in trial was 24’ row spacing by 25’ tree spacing (73 trees per acre)

Row spacing	Tree spacing	#trees/acre
20	20	109
21	21	99
22	22	90
23	23	82
24	24	76
25	25	70
26	26	64
27	27	60
28	28	56
29	29	52
30	30	48

Conclusions

- Tree spacing and configuration decisions needs to be done in conjunction with:
  - Microclimate
  - Soils
  - Rootstock
  - Variety

- Tree spacing/configuration choice is one of the most important decisions impacting long term productivity of orchard
  - Production from hedgerows tends to end up at about 2.8 to 3.2 tons/acre at maturity (depending on hedging frequency)
  - Traditional plantings can produce in the range of 4 tons/acre
  - Most productive orchards in our trials are traditional square spacing at traditional spacings


Thank you
Thanks to the California Walnut Board for funding various aspects of this work